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Research Article

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Selection of High Yielding Land Races of Seabuckthorn From Wild Seedling Population in Lahaul and Spiti District of Himachal Pradesh, India.

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ABSTRACT
A field study was undertaken to select high yielding land races of seabuckthorn from existing wild population of seedling origin in Lahaul and Spiti district of Himachal Pradesh. To select the superior land races intensive survey were carried in the district. Initially the selection of promising genotypes was made on the basis of some novel morphological and biochemical characters. The morphological characters like large fruit size, maximum fruit weight, yield per plant, less number of thorns per 10 cm shoot length, higher biomass yield and biochemical characters like higher Vitamin-C (mg/100 g), Oil content (%) and β–carotene mg /100 g were taken in consideration. The variation in fruit weight ranged from 10.23 g -36.56 g / 100 berries and yield from 0.20 kg – 5.5 kg /plant. Among the different species found growing in the area *H salicifolia* had maximum yield potential followed by *H. rhamnoides and H. tibetana*. In the beginning ten land races were selected on the basis of some superior morphological and chemical characteristics out of which three land races are finally identified and selected on the basis of correlation between morphological and biochemical characteristics for specific purpose. Out of these three land races one is *H. salicifolia* selection from Lahaul is a valuable specie which is high yielding (5.5 kg berries/ plant), large fruit size (36.56 g/ 100 berries) and richest in Vitamin C content and having less number of thorns. Another two land Races belongs to *H. rhamenoides* (one from Lahaul and one from Spiti valley) are rich in oil content which may be used for pharmacutical purposes.
Keywords: Seabuckthorn, variation, Land races, yield, fruit size, correlation.

INTRODUCTION
Seabuckthorn (*Hippophae rhamnoide* L) is also known as golden bush of the mountainous region in cold climates. The plant grows naturally in sandy soil in cold desert areas in India. It is valuable plant resources with high value of ecology and medicinal properties. Naturally, seabuckthorn is found in Siberia, Central Asia, Caucus, China, Mangolia, Germany, India, Finland and Denmark (Penteleeva and Zubareb 2001). It is rich source of anti-oxidants vitamin –C, E, carotenoids and flavonoids, and being used in food cosmetics and health industries in many countries. Total area under seabuckthorn is about 3.0 million hectares worldwide, both cultivated and wild. Around 90% of world's Seabuckthorn is found in China, Mongolia, Russia, Northern Europe and Canada. China is the largest producer of Seabuckthorn in the world (Stobdan and Phunchok, 2017). In China total area under wild Seabuckthorn is 740,000 ha and that of cultivated field is over 400,000 ha. In India total area under Seabuckthorn is 13,000 ha and approximately 600 tons of berries are harvested annually from wild plants. Ladakh is the major site for natural Seabuckthorn resource with over 70% of the total area under in the country (Stobdan and Phunchok, 2017). As seabuckthorn is polymorphic in nature, so in the natural habitat one can find a great diversity of plants which differs in morphological and biochemical features and in turns offers a great scope for selection of promising genotypes. The potential of Seabuckthorn has been realized by several research and development organizations like Defense Research & Development Organization (DRDO), Department of Biotechnology (DBT) and Department of Science & Technology (DST) Govt. of India, and CSKHPKV Palampur and initiated several projects in early nineties. Since there is no cultivated variety in India till no, therefore selection of desirable forms from natural population is the need of the hour. Huge variation in various characteristics in natural population will be helpful in genetic improvement of this plant.

MATERIALS AND METHODS
The present study was carried out in the Lahaul and Spiti district of Himachal Pradesh in India during the year 2008-2011. The Lahaul & Spiti district lies between 31^0 44' 57" to 32^0 59' 57" N latitudes and 76^0 46' 29" to 78^0

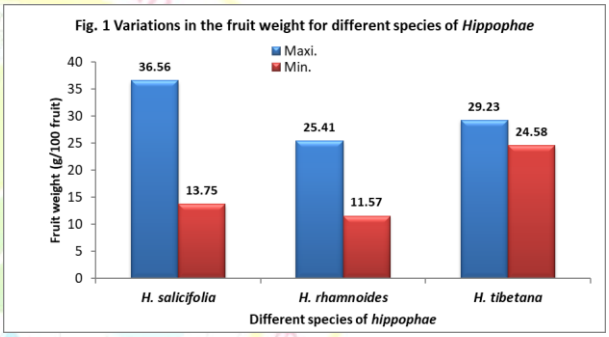
41' 34" E longitudes and covers approximately 13,835 km^2 area with an altitudinal range of 2400 to >6600m above mean sea level. The climate of the area varies from dry temperate, semi-arid and alpine type. The area remains snow covered almost for six months and receives up to 120 to 750 cm average snowfall year^{-1}. Rainfall varies from 10 - 300 mm year^{-1} and temperature -19^0 to +32^{0}C. To select the superior land races, intensive survey of the natural seedling population (67 locations) was carried in district during 2008-2012. Initially, the selection of promising genotypes was made on the basis of some novel morphological characters like large fruit size, maximum fruit weight, yield per plant, a smaller number of thorns per 10 cm shoot length and higher yield. These physical parameters were recorded at site. The samples were sent for chemical analysis to the Department of food and Nutrition, College of Home Science CSKHPKV Palampur. Biochemical characteristics like higher Vitamin-C (mg/100 g), oil content (%), anthocyanin content (mg/100 g), TSS (^{0}B), acidity (%) and β–carotene mg /100 g were analysed. The final selection of the superior genotypes was made on the basis of correlations between morphological and biochemical characteristics.

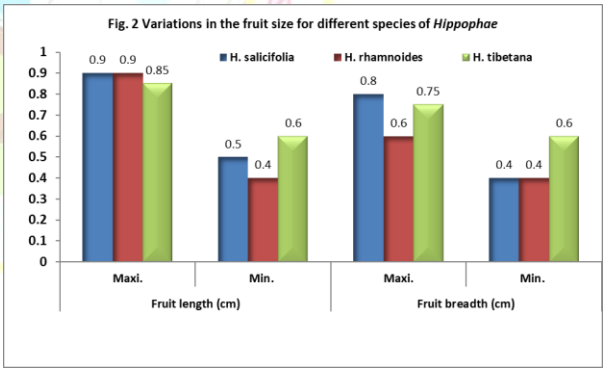
RESULTS AND DISCUSSION

During survey, three species of seabuckthorn (*H. rhamnoides* ssp. *turkestanica*, *H. salicifolia* and *H. tibetana)* were found in different parts of the district. Distribution pattern showed that in Lahaul and Spiti, these species are found at different locations in isolation as well as in combinations. Among all the species, *H. rhamnoides ssp. turkestanica* showed wider range of distribution followed by *H. salicifolia* and *H. tibetana*. In general variation of fruit weight of *H. salicifolia* varied from 13.75 - 36.56 g / 100 berries; *H. tibetana* (24.58 – 29.23 g / 100 berries) and *H. rhamnoides* sub sp. *turkastanica* (11.57 – 25.41 g / 100 berries) as shown in Fig. 1. Among all the species, *H. salicifolia* showed maximum fruit weight 36.56 g / 100 berries selected from Tinu village followed by *H. tibetana* 29.23 g /100 berries from Lossar and *H. rhamnoides* sub sp. *turkastanica* 25.44 g /100 berries from Jispa. The fruit colour and shape of *H. rhamnoides* sub sp. *turkastanica* varied from red, orange and yellow with ovoid, oblong, depressed shape; for *H. salicifolia* yellowish with rounded shape; however, for *H. tibetana* orange with rounded shape. *H. rhamnoides* sub sp. *turkastanica* showed highest number of thorns per 10 cm shoot length followed by *H. tibetana* and *H. salicifolia*. Fruit size *of H. rhamnoides* sub sp. *turkastanica,* varied from 0.5 x 0.4 - 0.9 x 0.6 cm; *H. salicifolia* 0.4 x 0.4 - 0.9 x 0.8 cm and for *H. tibetana* from 0.6 x 0.6 - 0.85 x 0.75 cm (Fig. 2). On the basis of novel morphological characters, ten land races were selected. Out of these land races one is of *H. salicifolia* from Tinu village and 9 of *H. rhamnoides* sub sp. *turkastanica i.e.*, 4 from Lahaul valley (Darcha, Jispa, Gemur, Chaaling) and 5 from Spiti valley (*i.e.*, Schiling-1, Schiling-2, Shego-1, Shego-2, Rangrik) were selected (table 1). The physical characteristics of different land races is given below (table 1):

Table 1. Morphological characteristics for selected land races of Seabuckthorn species

Location	Altitude (m amsl)	Yield (kg/ plant)	Colour	No. of thorns / 10 cm Shoot
Lahaul valley- *H. rhamnoides* sub sp. *turkastanica*				
Gemur	3020	4.2	Orange	6
Jispa	3050	5.0	Red	7
Darcha	3210	4.5	Red	6
Chaaling	3200	4.0	Yellow	6
H. salicifolia				
Tinu	3100	5.5	Yellow	4
Spiti Valley- *H. rhamnoides* sub sp. *turkastanica*				
Schiling - 1	3420	5.0	Orange	7
Schiling - 2	3420	5.2	Red	7
Shego - 1	3535	4.6	Red	9
Shego - 2	3535	4.3	Yellow	8
Rangrik	3615	4.5	Orange	7





The data in Fig. 3 shows variation among the bio-chemicals characteristics irrespective of the species. The vitamin-C, β–carotene and anthocyanin content varied from 402-930.14, 0.63-2.66 and 2.47-5.21 mg/100 g fruit, respectively. The pulp oil content varied from 3.8 % to 5.75 %, TSS (10-16 ^{o}B) and acidity (2.09-5.08%). It was observed that vitamic-C content was higher in *H. salicifolia as* compared to *H. rahmnodes*. However, percentage of oil content was more in H. *rahmnodes* as compared to selections from *H. salicifolia.* The findings are in line with the findings of Singh and Singh (2001). The variations in the biochemical characteristics are presumably due to the climatic and altitudinal variations. Singh et.al (2015) has also evaluated some exotic forms

of seabuckthorn in Lahaul and while comparing with local selection, local seabuckthorn has been found better in various parameters as compared to the exotic forms.

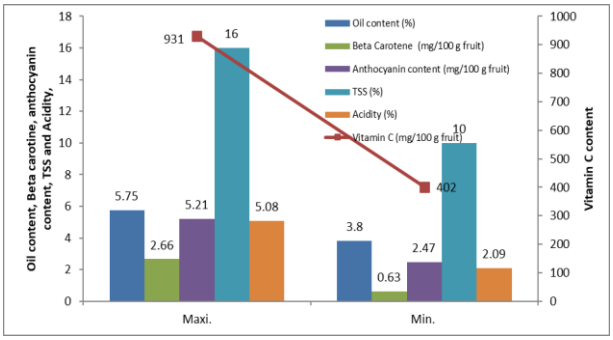


Fig. 3. Variation in chemical characteristics of seedling selections of seabuckthorn from Lahaul and Spiti district of Himachal Pradesh.

At first, five land races from Lahaul valley and five from Spiti valley were selected on the basis of superior morphological characteristics like large fruit size, higher yield (> 4 kg/tree) and less number of thorns. Out of these 10 land races, three land races (*H. salicifolia* from Tinu, *H. rhamnoides* from Jispa and *H. rhamnoides* from Spiti) were finally identified and selected on the basis of correlation between morphological and biochemical characteristics. The final selection was made because of some novel morphological characters like large fruit size, maximum fruit weight, yield per plant, less number of thorns per 10 cm shoot length and higher yield. In the present studies the fruit size was better in *H. tibetana* but it has very low yield so we have discarded this specie. The Russian has developed several varieties over last 70 years which are characterized by large fruit size, high productivity, mild thorny and high in oil, carotenoides but low in vitamin-C (Singh and Zubarev 2014). The wide variability in biochemical properties indicates the genetic potential seabuckthorn in Himachal Pradesh.

Table 2. Correlation between physical and bio-chemical parameters of *Hipophae spp*

	Yield (Kg/ plant)	Fruit weight g/100 fruits)	No. of thorns/ 10 cm shoot	Altitude (m)	Average fruit size Lx B (cm^2)	TSS (^{0}B)	Oil content (%)	Vitamin -C (mg /100 g)	Anthocyanin (mg/ 100 g)	Flavonoides (%)	Juice yield (%)
Yield (Kg/plant)	1.000	+0.520	-0.067	-0.083	0.131	-0.312	+0.093	+0.044	-0.037	-0.487	+0.676
Fruit weight g/100 fruit)		1.000	-0.458	-0.731	+0.592	-0.568	+0.662	+0.836	+0.314	-0.365	+0.289
No. of thorns/ 10 cm shoot			1.000	+0.639	-0.377	+0.214	-0.338	-0.613	-0.233	+0.384	+0.218
Altitude (m)				1.000	-0.518	+0.524	-0.609	-0.968	-0.410	+0.484	-0.432
Maximum fruit size Lxb (cm^2)					1.000	-0.570	+0.683	+0.618	-0.250	-0.643	-0.204
TSS (^{0}B)						1.000	-0.173	-0.140	+0.257	+0.905	+0.346
Oil content (%)							1.000	+0.688	-0.133	-0.846	-0.232
Vitamin-C (mg/100 g)								1.000	+0.455	-0.572	-0.177
Anthocyanin (mg/100 g)									1.000	+0.791	-0.671
Flavonoides (%)										1.000	Not cal
Juice yield (%)											1.000

Correlations between various characteristics of seabuckthorn were worked out (Table 2). It was observed that fruit yield is positively related with fruit weight, size, juice yield, oil and vitamin-C content of fruit. Manohar Lal et.al (2011) also observed positive correlation with the various morphological and chemical characteristics of different accessions of seabuckthorn from Lahaul & Spiti and Kinnaur district of Himachal Pradesh. Further fruit weight has positive correlation with fruit size, oil content, vitamin-C, juice and anthocyanin content but negatively correlated with flavonoide contents. Skundon (2008) has compiled the work of various authors regarding correlations between morphological and biochemical characteristics of seabuckthorn. The various research workers have observed positive correlation between fruit weight and vitamin –C. Altitude has also shown positive relation with TSS and flavonoide contents. Further it was observed that oil content in fruit is positively correlated with vitamin-C; vitamin-C with anthocyanin content and anthocyanin content with flavonoides. Present finding are in line with Fefelov (1988) who also observed positive relation of vitamin-C with fruit oil content. This suggests that, the effective selection of high yielding seabuckthorn from seedling population could be achieved by selecting large fruit size. On the basis of these, correlation studies finally three land races were selected.

As reported by Arimboor et al. (2006) the fruits of Indian Hippophae species have higher potential compared to the Chinese and Russian Hippophae. Therefore, these selections, are of interest for use in breeding program, horticulture plantation in marginal and forest land. The details characteristics of three best forms for practical use are given below.

Selection-1 (LHST): The selection belongs to *Hippophae salicifolia.* The plant is of medium size (3.5 m) having less number of thorn (4.2 thorn/ 10 cm shoot), large leaf size (length 9.3 x width 0.9 cm) and high yielding (5.5 kg / tree). Fruits are round (length 0.9 x width 0.8 cm), yellow with average weight 36.56 g / 100 fruits. Chemical composition of fruit: vitamin-C content (930.14 mg/100g fruit wt.); oil content (4.83%); β-carotene (1.13 mg/100g fruit wt.) anthocyanin content

(4.75 mg/100g fruit wt) and TSS (11.0°B). Fruit matures in last week of October. Suggested use of the selection is for horticulture purpose especially for juice extraction and for breeding for higher yield and large fruit size.

Selection-2 (LHRJ): The selection belongs to *Hippophae rhamnoides.* The plant is of medium size (2.9 m) having 7 thorn / 10 cm shoot, medium leaf size (length 5.8 x width 0.8 cm) and high yielding (5.0 kg / tree). Fruits are small (length 0.8 x width 0.6 cm), red with average weight 25.44 g / 100 fruits. Chemical composition of fruit: vitamin-C content (464.80 mg/100g fruit wt.); oil content (5.42%); β- carotene (2.66 mg/100g fruit wt.) anthocyanin content (5.15 mg/100g fruit wt) and TSS (10°B).

Selection-3 (SHRS-II): The selection belongs to *Hippophae rhamnoides.* The plant is of medium size (2.8m) having 7 thorn / 10 cm shoot, medium leaf size (length 5.1 x width 0.7 cm) and high yielding (5.2 kg / tree). Fruits are (length 0.6 x width 0.5 cm), red with average weight 17.28 g/100 fruits. Chemical composition of fruit: vitamin-C content (475.26 mg/100g fruit wt.); Oil content (5.74%); β- carotene (2.64 mg/100g fruit wt.) anthocyanin content (5.25 mg/100g fruit wt) and TSS (13°B).

CONCLUSION

Selection of *H. salicifolia* is a valuable specie because it is having high yield (5.5 kg berries/ plant), large fruit size (36.56 g/ 100 berries) and is richest in Vitamin C content and having less number of thorns. Therefore, it is highly suitable for cultivation in Lahaul district and suitable for juice production. Another land races belongs to *H. rhamnoides* are rich in oil content which may be used for pharmacutical purposes. Among the different land-races, H. *salicifolia selection* from Tinu village of Lahaul is the most valuable resource for breeding and cultivation purposes. The present study will be helpful for local farmers and policy makers to develop effective action plan for sustainable use and conservation management of seabuckthorn in cold desert region in particular and Himalayan region in general.

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